Part V
Seismic Safety Element

San Diego County General Plan

COUNTY OF SAN DIEGO
ENVIRONMENTAL DEVELOPMENT AGENCY
January 1975

Acknowledgements

This document has been prepared by the Seismic Safety Subcommittee of the Citizens' Committee on the General Plan with the assistance of County staff. The members of this subcommittee have given long hours and the benefit of their expertise to the preparation of the Seismic Safety Element. The subcommittee wishes to take this opportunity to express their appreciation for the work and patient guidance of the staff of the Planning Department, Office of Environmental Management and Environmental Development Agency. In addition, the subcommittee wishes to thank the kind assistance of Mr. Greer Ferver and Mr. John Burton who lent their support to the preparation of this element. A special note of thanks to Staff Planner Mike Wright and to Paul Ross, without whose help this element would not have been completed.

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**Appendices C thru G for information only-not adopted. Available from the Planning Department.*
Note: Appendices H and I, Faults & Epicenters and Landslides maps attached. (Not adopted)

Seismic Safety Element Distribution List

The following organizations or persons were extended the opportunity to critique the draft element for the purpose of maximizing the level of public and professional input to the element.

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Summary

In January, 1974, the Board of Supervisors appointed the Seismic Safety Subcommittee to the Citizens' Committee on the General Plan. Their charge was the preparation of an element of the General Plan which would incorporate into the planning process procedures to minimize the loss of human life and property damage from seismic and geologic phenomena.

The major topics addressed are an evaluation of the state-of-the-art and existing data on the subject; the abatement of hazardous structures; disclosure and delineation of known hazardous sites; and the coordination of state and local efforts to minimize loss before an event occurs.

The recommendations of the subcommittee to reduce seismic risk in San Diego are in the Policies and Action Programs portion of the element. The major conclusion of the element is that the appointment of a Regional Seismic Safety Committee will provide a regional approach to reducing the County's seismic and geologic hazards. Other programs provide for the preparation of standards and procedures for the approval of real estate development in hazardous areas; designation of a "County Geologist"; a survey of hazardous structures; amendment of The Zoning Ordinance to require geologic reports prior to development of land in the Alquist-Priolo Geologic Hazard Zones; collection of a geologic "Data Bank"; amendment of the Environmental Impact Report process to better account for geologic hazards; determination of the potential tsunami hazard; and consideration in the tax assessment process of designated hazardous areas.

CERTIFICATES OF ADOPTION

I hereby certify that this plan is the Seismic Safety Element of the San Diego County General Plan and that it was approved by the San Diego County Planning Commission.

10/11/74
Date — Margaret E. Ferguson, Chairman

Attest: Bruce H. Warren, Secretary

I hereby certify that this plan is the Seismic Safety Element of the San Diego County General Plan and that it was adopted by the San Diego County Board of Supervisors.

1-7-75
Date — Dick Brown, Chairman

Attest: Porter D. Cremans, Clerk of the Board

State Authority for the Seismic Safety Element

In 1971, the California Legislature amended Section 65302 of the Government Code to require the addition of a Seismic Safety Element to the General Plan. Subsection f of Section 65302 (Government Code) requires that cities and counties prepare such an Element. *See Appendix F.*

Risk Evaluation

The consideration of risk is central to the State and other professional association guidelines suggested to assist the preparation of the Seismic Safety Element. These guidelines suggest that levels of risk are a community decision for policy-making bodies to determine. Because of their lack of specificity, general formulae such as the levels suggested in Meeting the Earthquake Challenge are not practical to apply to San Diego County.

There are two central themes to risk evaluation: public disclosure and public responsibility. Public disclosure is a consideration that led to the committee recommending various programs to increase public awareness of seismic risk in San Diego County without creating undue concern or over-reaction. Public responsibility is centered around the appropriate response of San Diego County to potential risk-creating situations. There is no "safe" level of earthquake risk since safe is a subjective judgement. The problem with quantitative approaches lies in the complexity of principles upon which risk judgements are made. Risk is a function of the underlying lithology of the site and its proximity to an earthquake epicenter and varies with the use of the structure as well as the type, kind and quality of construction. Given those independent factors and economic and social impacts, the mechanical determination of an arbitrary level of risk is too simplistic.

Nevertheless, to ignore the threat of an earthquake occurrence is to accept risks ranging from insignificant to catastrophic. Blind acceptance of such risks is not justifiable or necessary. The Committee investigated various methods of determining levels of risk and approved three general guidelines:

- In structures where the risk could involve the loss of life, measures such as building occupancy limitations, renovation or removal programs should be undertaken.

- In all planning and future development proposals, consideration must be given to the long-range physical and economic impact to a community in the event of a seismic or geologic occurrence. Earthquake recurrence factors are too recent a concept to use as justification for building in what may otherwise be a hazardous area.

- In situations not covered, it will be necessary for the Regional Seismic Safety Commission *(see Action Program 1.1)* to interpret policy and recommend design standards based on this Element and their judgement as an interdisciplinary team.

The entire Seismic Safety Element is an attempt to recognize and define risks within the limits of present knowledge and prescribe programs to mitigate or lessen that risk.

Chapter 2
Findings

The following is a summary of the major findings of the research program for the San Diego County Seismic Safety Element:

Finding 1 San Diego County is located in a region with significant seismic and geologic hazards including the San Jacinto and Elsinore Fault systems. (McEuen, p. 53)

Finding 2 The identified active or potentially active faults *(see Appendix B, Glossary)* in the San Diego region are as follows (Jennings, CDMG):

a. San Jacinto
b. Elsinore
c. La Nacion
d. Rose Canyon
e. Sweetwater
f. Superstition Mountain
g. Agua Caliente
h. Tijuana-San Miguel
i. Agua Blanca-San Clemente
j. Coyote Creek
k. Imperial
l. San Andreas
m. Newport-Inglewood
n. Earthquake Valley

Finding 3 Information on earthquakes within the County prior to 1932 is incomplete. Subsequent to that date, California Institute of Technology began to monitor earthquakes in the Southern California region. Further study of the early records could define more completely the nature and extent of seismic activity. (Ross)

Finding 4 The State Division of Mines and Geology has identified a series of special study zones (geologic reports required) along the San Jacinto Fault for local implementation and will complete delineation of the Elsinore Fault zones during Fiscal Year 1974-75. If hazardous activity is verified, the Rose Canyon and La Nacion Faults will be zoned in Fiscal Year 1975-76. *See Appendix C*

Finding 5 The base information included in the Element can be augmented by a continuing research program. A data bank (Bigger, p. 15) incorporating reports required with proposals for new construction (i.e., geologic, soils, or environmental impact) would be extremely useful.

Finding 6 Building and Grading Codes are regulations established under the police powers vested in local governmental entities as a result of mandatory or enabling legislation enacted by state legislative bodies for the purpose of guiding the design and construction of buildings or structures. These have evolved over a period of many years as a result of experience demonstrating a need for minimum standards to safeguard people and property.

Finding 7 The Uniform Building Code requires the performance of special foundation engineering and soils investigations of the proposed development site based upon the type of hazard exposure. *See Table 1*

Finding 8 The Uniform Building Code adequately regulates for seismic factors. However, its regulations can be supplemented by additional requirements in identified areas of exceptional seismic and geologic hazard to reduce the level of risk.

Finding 9 Current regulations on soil reports are adequate except in areas of potential liquefaction.

Finding 10 The County Grading Ordinance adequately considers problems of slope stability. However, the standards do not consider seismic aspects of slope stability.

Finding 11 The landslide hazard in the County is considered to be of a nature that would require a significant volume of research and involve field investigations to identify the formations and sites upon which standard development practices would be unsafe.

Finding 12 Structures which may possibly present a hazard to life during a relatively minor earthquake may exist at various locations in the County. As yet they are unidentified.

Finding 13 The County's Seismic Safety Program can be coordinated with the other cities' and state's seismic program to assure a regional reduction of risk from seismic and geologic activity The Joint Committee on Seismic Safety made up of California Assemblymen and Senators has recommended the establishment of a State and Regional Seismic Safety Commission. The Committee also recommended state funds be used to maintain Regional Seismic Safety Commissions. (Joint Committee, p. 158)

Finding 14 Programs to update the County's Emergency Plan for response to natural disasters from earthquake, tsunami, and seiche emergencies will be identified in the Public Safety Element of the County General Plan.

Finding 15 Seismic and geologic hazard zones identified within the County are partially on government-owned lands. Land trades that will increase the amount of hazard-zone lands in government ownership is compatible with the goal of this element.

Finding 16 Property owners are not informed or compensated for land use constraints due to the identification of seismic and geologic hazard zones under current deed transfer and tax assessment procedures.

Finding 17 Tsunami damage experienced along the San Diego County coast has been limited to the harbors. The records on tsunamis, however, are even less complete than for those of earthquakes *(see Finding 3)*. A remote or locally generated tsunami capable of damage to shoreline development and harbors is a possibility. (McEuen, p. 53)

Finding 18 The land form that is San Clemente Island suggests several thousand feet of dip (vertical) separation along the San Clemente Fault. The Fault may be capable of producing an earthquake of 7.7 magnitude (credible). (McEuen, p. 29, Appendix A) It is oriented so as to produce the potential for tsunamis on the San Diego County coast in the event of adequate dip slip (vertical) separation.

Finding 19 Along the unincorporated coast of San Diego County there are three areas of potential tsunami inundation:

a. The south side of the mouth of Batiquitos Lagoon;

b. Moonlight Beach, Encinitas; and

c. The mouth of San Elijo Lagoon.

Table 1

INFORMATIONAL GUIDE
to
CURRENT SITE STUDY REQUIREMENTS

LOCATION (Refer to Maps - 1, and 2, attached)	**STUDY REQUIRED**	**ACTION REQUIRED IF HAZARD VERIFIED**
In Special Study Zone of Active Fault Trace	Geologic Study Required Prior to Building Permit	No Structure for Human Occupancy on Trace
Major Structures on Designated Fault Traces	Geologic Study Required at Building Inspector's Discretion	Special Design
Geologic Formation or Bluff Prone to Landsliding	Soils Study Required at Building Inspector's Discretion	Special Grading, Foundation or Structural Engineering or Additional Setback
Liquefaction Potential	Soils Study Required at Building Inspector's Discretion	Geotechnical Study and Special Design
Tsunami or Seiche Potential	None at Present	-

Chapter 3
Goal and Objectives

Goal

The Seismic Safety Element Goal is to minimize the loss of life and destruction of property in San Diego County by making planning recommendations giving consideration to seismic and geologic occurrences and their long-range impact on the community.

Objectives

In order to accomplish the above goal, the following are the objectives of the Seismic Safety Element of the San Diego County General Plan:

Objective 1 If a project is proposed in an area classified as seismically and geologically hazardous, the proposal should establish that:

a. The unfavorable conditions do not exist in the specific area in question; and/or

b. That the development is consistent with the policies of the County of San Diego as set forth in this element.

Objective 2 Establish a project review process that allows consideration of seismic and geologic hazards at the earliest possible point in the development process, preferably before comprehensive engineering work has commenced.

Objective 3 Sponsor a program to abate or modify existing hazardous structures or their use or occupancy when loss of life is a factor.

Objective 4 Sponsor programs of public information to increase awareness of seismic and geologic hazards.

Objective 5 Integrate into the planning and development review process, policies and programs that will observe the physical constraints of the region as they relate to seismic and other geologic phenomena.

Chapter 4

Policies and Action Programs

To fulfill the objectives of the Seismic Safety Element, these Policies and Action Programs are deemed necessary to reduce the risks associated with seismic and geologic hazards in San Diego County as they are identified in this Element:

POLICY 1 The County will establish land utilization limitations consistent with existing and evolving seismic and geologic knowledge. Within designated areas where population densities or structures may be inappropriate to the seismic and geologic hazards present, measures shall be taken to prevent further expansion, modification or development of inappropriate land use when loss of life is a factor. Similar measures shall be taken to promote more compatible land uses for future development.

Action Program 1.1 Establish a Regional Seismic Safety Committee to provide technical assistance to State and local government and recommend criteria and minimum development standards to reduce the level of seismic risk in San Diego County. The Committee shall be an interdisciplinary team consisting of a Geotechnical (Civil) Engineer, a Building Inspector, an Urban Planner, a Geologist and a Structural Engineer. The selection of technical interdisciplinary team members shall be from a recommendation of the professional organizations concerned.

Action Program 1.2 The Committee may also consist of a representative of the County and each city within the County (if so selected by their respective jurisdictions), a representative from the Port District, the Office of Emergency Services and a citizen member.

Action Program 1.3 Hire a staff to the RSSC who shall be designated the "County Geologist." The County shall budget this position within the Environmental Development Agency. The RSSC shall interview candidates and forward its recommendation to the County.

Action Program 1.4 Direct the RSSC to undertake the following activities:

- Prepare a report format and review procedure for geologic reports for hazardous areas. The format will meet the criteria of the State Geologist for reports required in the Alquist-Priolo Special Study Zones.
- Recommend standards and criteria to be applied to areas of hazard to real estate development.
- Define criteria and propose actions to abate significant hazards to human life. Recommendations should address unreinforced masonry and aged, dilapidated structures; structurally unstable architectural appendages and ornaments such as parapets or marquees; and give consideration to the type of ground on which structures rest.
- Recommend, where appropriate, additions to the Alquist-Priolo Special Study Zones.
- Recommend, where appropriate, changes in local ordinances.

Action Program 1.5 Amend County Ordinance 4260 to require specific geologic reports for hazardous areas (as they become identified on Appendix H. Utilize material prepared by the RSSC.

Action Program 1.6 Adopt standards and criteria to be applied to areas of hazard to real estate development based on recommendations of the RSSC. These standards shall be an interpretation of County policy for developments proposed for areas of active faulting, slope instability and landsliding, liquefaction and tsunami. Limitations on development will correspond to the degree of hazard present.

Action Program 1.7 Conduct survey to identify those structures in the unincorporated area which were built prior to 1933. Buildings built prior to 1958 which exhibit identifiable hazard to human life shall also be identified. Consider adoption of amendments to Ordinance 4260 Section 203 as recommended by the RSSC.

Action Program 1.8 Add a Natural Hazard Overlay Zone to The Zoning Ordinance indicating that major structures *(see Appendix B, Glossary)* not be permitted, and that uses permitted meet standards indicated by geotechnical studies. Initially, this zone will be applied to the Alquist-Priolo Special Studies Zones as defined by the State Geologist. The manner in which additional zoning is geographically delineated will observe policy in this element and the recommendations of the RSSC.

Action Program 1.9 Encourage the International Conference of Building Officials to make changes in the Uniform Building Code that will recognize the Structural Engineers Association of California Seismology Committee recommendations and other new technology.

Action Program 1.10 Maintain a triannual review of County ordinances to insure that they are current with the standards of the Uniform Building Code and recommendations of the RSSC as they may be applied to the County of San Diego.

POLICY 2 The County will utilize existing and evolving geologic, geophysical and engineering knowledge to distinguish and delineate those areas which are particularly susceptible to damage from seismic and other geologic phenomena.

Action Program 2.1 Determine in the initial environmental assessment the potential for seismic or geologic hazard. If any significant hazard is verified by the County Geologist, a geologic report may be required as part of the Environmental Impact Report.

Action Program 2.2 Seek funding for a study to determine tsunami run-up for the San Diego region. The study must identify 20, 50 and 100-year recurrence intervals taking into account offshore and remote faulting activity, benthic (submarine) topography, and wave energy orthogenals (lines) from all potential tsunami sources in the Pacific. Such a study might be undertaken by the National Oceanic and Atmospheric Administration or by Scripps Institute of Oceanography.

Action Program 2.3 Amend The Zoning Ordinance, on the basis of data obtained through the study recommended in Action Program 2.2., to restrict land use using the following criteria:

a. No human occupancy within 20-year run-up.

b. Low intensity use only in 50-year run-up.

c. Essential public facilities, such as schools and hospitals, located only on sites above the 100-year run-up.

Action Program 2.4 Determine in the initial environmental assessment the potential for tsunami hazard subsequent to the publication of said data. If any significant hazard is verified by the County Geologist, it shall be addressed in the Environmental Impact Report.

Action Program 2.5 Initiate a study to supplement Appendix I identifying the landslide and liquefaction prone soils of the unincorporated area. The study shall make recommendations to amend the appropriate land development ordinances. As a minimum, the County shall amend Ordinance 4260 Section 302d to require soil or geotechnical reports within the delineated areas subsequent to adopting Map 2 as an amendment to this element.

Action Program 2.6 The data and recommendations from Action Program 2.5 shall be interpreted by the RSSC, which may recommend establishment of appropriate measures to require special design considerations for real estate development projects within the delineated areas.

Action Program 2.7 Direct the EDA and County Counsel to prepare an interim ordinance to require geologic reports for real estate development directly over or on traces of these designated faults *(see Map 1)*:

Elsinore
La Nacion
Sweetwater
Agua Caliente
Coyote Creek
Earthquake Valley

POLICY 3 The County shall expand its data base in geology and related disciplines.

Action Program 3.1 Direct the County Geologist (see Action Program 1.3) and the Office of Environmental Management to initiate a program to research and gather existing seismic and geologic data for the San Diego region. The program will, as a minimum, include the collection of soils, geologic, seismic, and environmental impact reports and their incorporation into a unified information retrieval system or data bank. The program will describe procedures for acquiring data from the various sources and agencies.

Action Program 3.2 Direct the Department of Building Inspection to keep development plans for major structures. These records are to be maintained for the life of the building.

Action Program 3.3 Direct the Office of Environmental Management to provide input to the State Geologist encouraging him to locate "Strong Motion" instruments on sites that will further refine the knowledge of geologic structures within the region.

POLICY 4 The County shall take into consideration delineated areas of seismic and geologic hazard land classification when:

- Government agencies make land trades or sales;
- Planning roads and utility networks;
- Planning future utility requirements; and
- Reassessing property.

Action Program 4.1 Encourage the use of data on known seismic and geologic hazards to guide the engineering and safe placement of essential public structures such as fire and sheriff facilities, County roads and utility systems.

Action Program 4.2 Encourage the trade or sale of privately owned land in geologic hazard zones into government ownership.

Action Program 4.3 Initiate actions to place geologic hazard zones on Assessor's Maps and request the Assessor to consider such designations in the assessment of land within said zones.

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Appendix A
Geotechnical Background

Causes of Earthquakes

According to the generally accepted theory, earthquakes are caused by the release of accumulated strain along fractures in the earth's crust. This release may be gradual (fault creep) or rapid (earthquakes). Frequent release of small increments of energy results in fewer destructive earthquakes. If a large amount of energy accumulates before release, the result is a potentially large destructive quake.

Factors Responsible for Earthquake Damage

Four factors determine the amount of damage that will occur during an earthquake. These are:

- Magnitude of energy released and seismic wave frequency;
- Distance from source;
- Way in which the ground at a site responds to seismic waves;
- Way in which a building at a site responds to seismic waves.

ENERGY RELEASE

Generally, longer faults are responsible for larger earthquakes. The amount of energy released has an exponential relationship to the length of continuous fault ruptures. Thus, it is important to know if faults which seem to line up are in fact on continuous fault or a series of shorter breaks. The characteristic quantity of the total energy released by an earthquake is measured on the Richter Magnitude Scale. This scale is logarithmic which means that an earthquake of magnitude 7.0 releases 100 times as much energy as one of magnitude 5.0. Magnitude is only a measure of energy released at the source and not necessarily directly proportional to the destructiveness of the earthquake. Actual effects and damages are measured on a local intensity scale - the Modified Mercalli scale. *See Appendix D*

DISTANCE FROM SOURCE

In a major earthquake (magnitude 7+) there is a strongly-felt, swaying ground motion many miles from the source or "epicenter." Motion could be felt over an area as large as the entire State of California in a major earthquake.

Moderate earthquakes (magnitude 6.0 to 6.9) can cause major damage and loss of life if they occur close to any urban area. Examples include:

YEAR	LOCALITY	DAMAGE	DEATHS	MAGNITUDE
1925	Santa Barbara	$ 8,000,000	13-20	6.3
1933	Long Beach	40,000,000	120	6.3
1971	San Fernando	443,000,000	64	6.6

TYPES OF GROUND RESPONSE

During an earthquake, most damage will be caused by a variety of kinds of ground movement, such as ground shaking, surface fault rupture, landslides and mudslides, liquefaction, and tectonic subsidence or uplift.

- Ground shaking causes by far the most damage during earthquakes. Property damage and deaths are caused by buildings being shaken during an earthquake. A poorly constructed building on "weak" ground twenty miles from the epicenter of an earthquake may be subject to greater stress than a strong building on more firm ground only a mile away. An epicenter is the point on the earth's surface directly over the "focus" or heart of an earthquake. The distance from the focus or center of energy release on the fault plain is also related to the intensity of ground shaking. Two points miles apart on the earth's surface may be a similar distance from the focus within the earth.

- Surface fault movement occurs only along the trace of active faults. Movement may be slow (creep) or rapid (earthquake). Smaller earthquakes may not be accompanied by surface fault rupture. In San Diego County damage from actual fault movement is probably only of concern in the northeastern portions of the County.

- Ground Failure

  - Landslides are commonly triggered by earthquakes and aftershocks. Failures are common on old landslides and oversteepened slopes such as roadcuts, building sites, sea cliffs, and stream-cut canyons. In San Diego County, major earthquake shaking could probably cause landslides along the sea cliffs, on mountain roadcuts, along the slopes of Palomar and Laguna Mountains and on a number of cut slopes in subdivisions in landslide prone areas.

  - Mudslides are precipitated by earthquakes in areas where saturated soil is present - a rare situation in San Diego County. They normally occur during the season of greatest precipitation in areas that have suffered a loss of vegetation from fires, road grading or brush clearing. This hazard is associated with the geographic characteristics of the County and not with the other seismic and geologic hazards.

  - Liquefaction is a mechanism of ground failure. Soil liquefaction is defined as the transformation of a granular material from a solid into a liquefied state as a consequence of increased pore-water pressures. (Youd, p. 1) It is caused by seismic vibration of fine sand or silt which is saturated with water. While there have been no well documented cases of liquefaction in the County, there are limited areas which must be considered potentially subject to liquefaction. The largest area subject to this hazard is around the margin of San Diego Bay, outside of County jurisdiction. The margins of coastal lagoons (San Elijo and Batiquitos) and possibly the lower courses of river valleys should be considered potential problem areas.

- Ground fractures may occur during an earthquake where there are uncompacted soils or an abrupt change in the depth to bedrock beneath the subsoil. Some soils affected by seismic vibrations may be compacted or lurch sideways causing cracks in the ground surface.

- Subsidence and uplift often accompany fault movement. Such movement affects harbor levels, the flow of water in canals and tunnels, and it distorts land survey lines. This phenomena is typically associated with the withdrawal of groundwater or petroleum; with large limestone deposits; with volcanism; or with

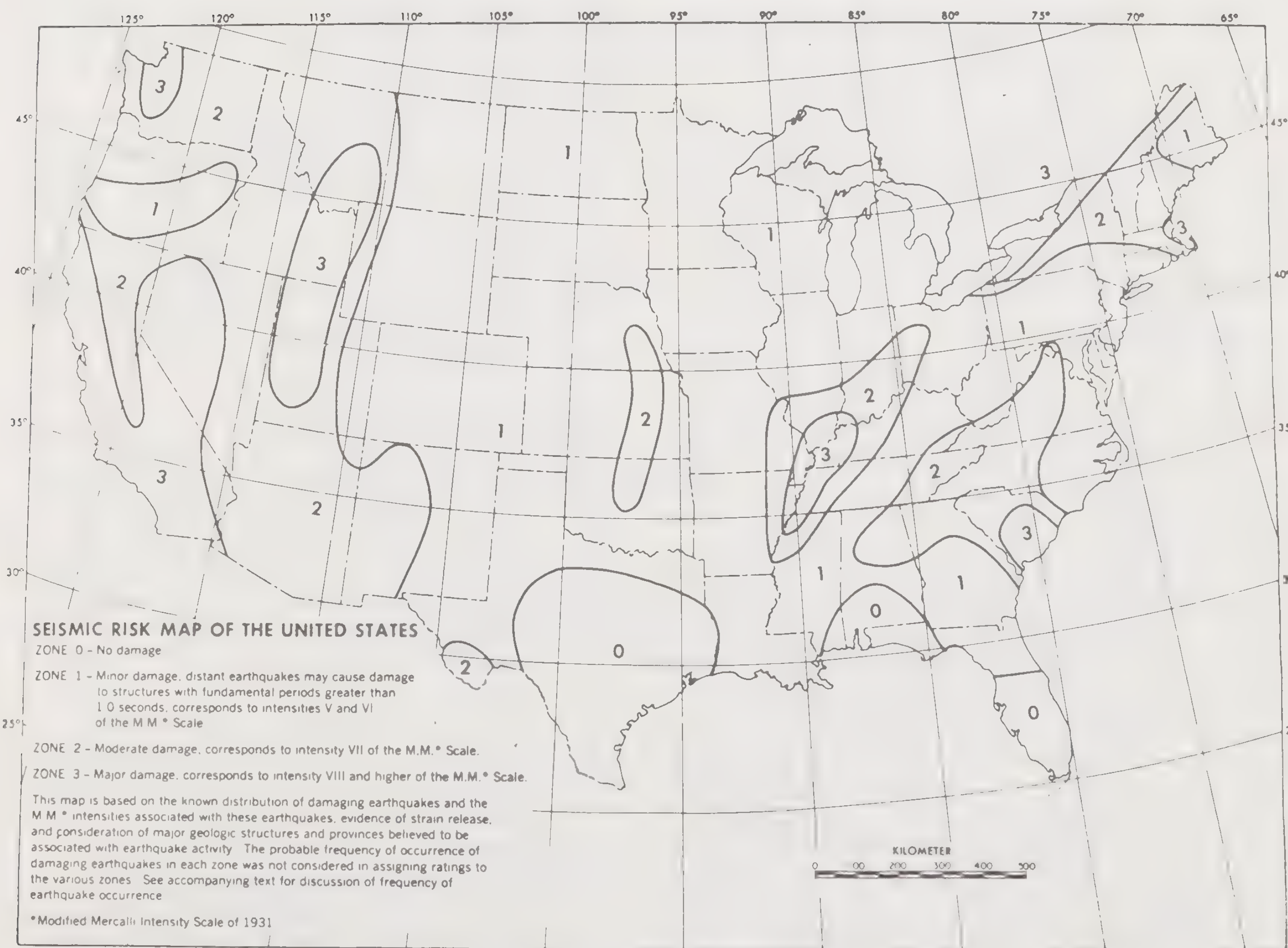
hydro-compaction. None of these constitute a significant problem in San Diego County.

- Response of structures to seismic shaking is a frequency-response problem. For this reason when the response period of a structure is magnified by the ground motion, a condition of quasi-resonance may occur and subject the structure to more stress, thus increasing potential for damage. The greatest concern, however, is the ability of a structure to deform without failure during the maximum seismic event for which it was designed.

For engineering design of certain "major structures" *(see Appendix B, Glossary)* calculations should include assumptions about the probability of an earthquake of a given magnitude and the way that energy is transferred by the soil at that site. For ordinary structures, other than on a fault trace, the risk does not merit extensive structural engineering studies or design.

Map - 1

SEISMIC RISK MAP OF THE UNITED STATES



(SOURCE: "Seismic Risk Studies in the United States" by S.T. Algermissen, Fourth World Conference on Earthquake Engineering, I:26 [1969])

IDENTIFICATION OF ACTIVE FAULTS AND OTHER FACTORS AFFECTING SAN DIEGO COUNTY

Global Framework

California is part of what is popularly known as the "Ring of Fire" which encircles the Pacific Ocean. The margin of the Pacific Ocean is marked by volcanic activity, active faults, and frequent earthquakes. In recent years, the geology of California has been reexamined in terms of theories of global tectonics. According to these new concepts, continent-sized blocks of the earth's crust are moving in respect to each other. Where these huge plates meet there is considerable friction and potential for large accumulations of strain.

San Diego County is located on that portion of California west of the San Andreas Fault on part of the "Pacific plate." We are moving north with respect to the rest of the American continent which is part of the "North American plate." This movement is distributed among several major faults including the San Andreas. In San Diego County there are two associated faults roughly parallel to this great tectonic complex. These are the San Jacinto and Elsinore Faults.

Regional Setting

For seismic considerations, the San Diego region extends approximately 60 miles beyond the County boundaries. San Diego County lies within a zone of high earthquake activity. (See Figure 1) It has experienced many local epicenters but no devastating earthquakes during the past two hundred years primarily due to the distance between urban centers and the sources of energy release. Using the published geotechnical data, only a subjective judgement can be made in evaluating whether the urban portions of the County are safe from damaging earthquakes or whether this area merely escaped strong earthquake activity during the period of record. Perhaps the San Diego coastal area is an area of low risk within a region of moderately high risk.

Current research on San Diego's earthquake hazard suggests that we should not be complacent. The continental shelf off San Diego is broken by numerous faults. The evidence for these faults is based on bathymetry, and a limited number of recorded epicenters. It appears that the extreme western portion of the coastal plain is actually a part of this faulted continental borderland that lies within a regional system of northwest trending faults exhibiting a complex pattern of vertical and lateral separation.

There seems to be a more localized group of related faults extending from San Ysidro, through San Diego and Mission Bays, and Rose Canyon. Although evidence that these faults have been recently active is not readily apparent, the possibility of movement is being studied by the California Division of Mines and Geology. *See Appendix C*

It has been suggested that the faults in Rose Canyon and the bay areas continue north and off-shore to connect the Newport-Inglewood Fault which was responsible for the 1933 Long Beach earthquake. This system may also be related to the active San Miguel Fault in Baja California. If there is indeed a continuous fault zone from northern Baja California to Long Beach, and the San Diego segment is only dormant, not inactive, then there is a cause for major concern.

Discussion of Individual Faults

- The <u>Elsinore Fault</u> is the largest, known active (see Appendix E) fault in San Diego County. It is approximately 135 miles long. The area of most probable activity is between Lake Elsinore and Vallecito Valley, a distance of about sixty miles.

  The maximum probable earthquake (magnitude 7.6) could cause moderate damage in the coastal area and serious damage in the rural urban centers of the central County. Numerous epicenters have been located near Elsinore and the related Agua Caliente and Earthquake Valley Faults. The largest

recorded quake on the Elsinore Fault had a Richter magnitude of 6.0.

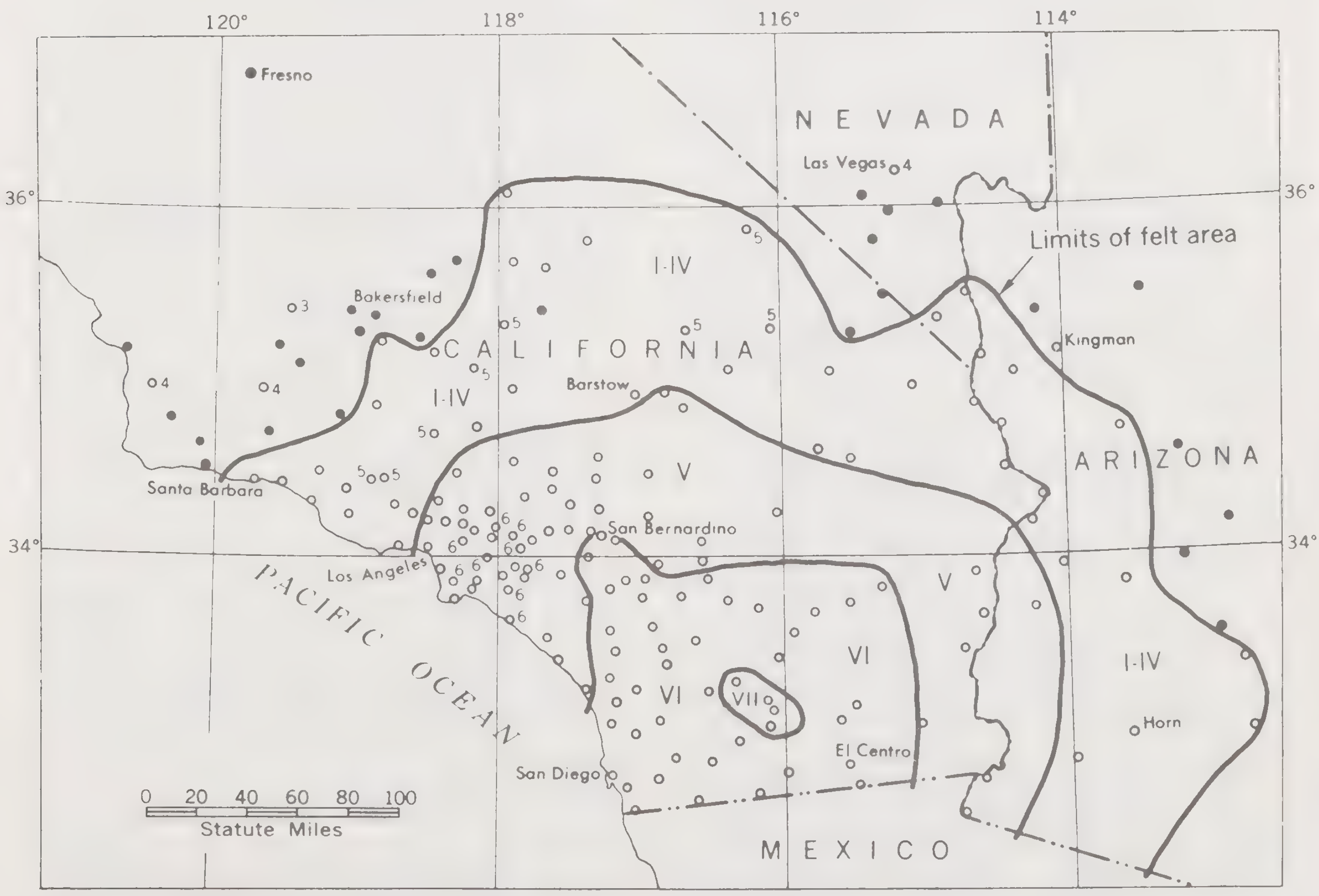
- The San Jacinto Fault is the most active, large fault within San Diego County. It extends for 125 miles from the Imperial Valley to San Bernardino.

  The maximum probable earthquake would have a magnitude of 7.5 to 7.8. (McEuen, p. 48) This would cause severe damage in Borrego Springs and Ocotillo Wells with moderate damage in the coastal area. The San Jacinto Fault has been active in historical times, producing an earthquake of VIII (Mercalli Scale) in 1890 and 1899. The Coyote Creek Fault, a branch of the San Jacinto, was responsible for the 1968 earthquake (magnitude 6.8) near Ocotillo Wells.

- The San Andreas Fault is outside the County but presents a hazard to the San Diego region. It extends for 650 miles from Baja California to the coast north of San Francisco. In the 1906 San Francisco earthquake (magnitude 8.3) there was movement along 124 miles of the San Andreas. There was ground rupture along the Fault during the 1857 Fort Tejon quake, another major event. In Southern California, the San Andreas extends from San Bernardino through the Whitewater Pass and along the east side of the Coachella and Imperial Valleys.

Map - 2

INTENSITY OF 1968 COYOTE CREEK EARTHQUAKE



Major damaging earthquakes are likely to originate on the southern segment of the San Andreas. The closest inhabited portion of San Diego County is 30 miles away and the coastal area is 85 miles -- about the distance of Anchorage from the epicenter of the 1964 Alaskan earthquake.

- The Rose Canyon Fault extends from La Jolla Cove, south through Rose Canyon, and along the east side of Mission Bay. Recent investigation indicates that there is considerable faulting in San Diego Bay associated with the Rose Canyon Fault which is apparently also continuous offshore to the north. (From M. P. Kennedy, CDMG report in press) It has been suggested that the Rose Canyon Fault is a part of a zone of faulting which includes the Newport-Inglewood Fault and the Vallecito and San Miguel Faults in Baja California. The Newport-Inglewood Fault was the source of the 1933 Long Beach earthquake (magnitude 6.3). Epicenters of earthquakes in the range of Intensity V to VI have been located near the Rose Canyon Fault system.

  At this time, published studies have not determined if the Rose Canyon Fault is part of a larger fault which extends continuously for 140 miles, or whether it is one of the several shorter faults. If this hypothesis is confirmed, there is a major cause for concern.

- The Sweetwater and La Nacion Faults are 4 to 6 miles inland from and parallel to the Rose Canyon Fault and San Diego Bay. Presumably, they are related to the fault system which created the depression now occupied by San Diego Bay and Mission Bay. The Sweetwater and La Nacion Faults do not appear to have been active in recent time.

- Offshore faulting is extensive along the coast of Southern California and Baja California. The bathymetric (seafloor topography) map shows numerous basins and ridges with steep slopes. This topography and some epicenter data indicates that the offshore area is extensively faulted. The San Clemente Fault, 40 miles off La Jolla is the largest offshore fault! It is 110 miles or more in length and is theoretically capable of generating a quake of magnitude 7.7. An earthquake of magnitude 5.9 occurred near the San Clemente Fault in 1951.

DEGREE OF FAULT ACTIVITY

The use of data on the recurrence of earthquakes on faults in the San Diego region is a matter of continuing debate among geologists. It is generally agreed that those faults which have been active in the recent geologic past are the ones most apt to move in the future. "Recent" is defined by the State of California as within the last 11,000 years. The Atomic Energy Commission is more conservative since they are concerned with nuclear reactors. They use a figure of 35,000 years.

Historic records in this region go back only 200 years. Of that period, the last 40 represent accurate technical data with the large events prior to that being merely described in newspapers or diaries. Recurrence intervals for most of the faults in the region would be based on technical data mixed with subjective judgement.

The Elsinore and San Jacinto Faults are exceptions in that they have exhibited enough activity in this century to warrant making statements on their respective degree of activity.

For the Elsinore Fault:

- One in sixty years at 7.3 magnitude.
- One in one hundred years at 7.6 magnitude (maximum credible).

For the San Jacinto Fault:

- One in ninety years at 7.3 magnitude.

- One in one hundred seventy years at 7.8 magnitude (maximum credible). (McEuen and Pinckney, p. 50)

LOCAL SOIL CONDITIONS, TOPOGRAPHY AND GROUNDWATER

Local soil conditions and topography tend to modify the nature and intensity of seismic waves emanating from bedrock. The primary effect of local soil conditions is to amplify motion intensities at some frequencies and occasionally diminish them at others. Typically amplification is greatest at the characteristic (fundamental) period of the soil deposit. The amount of amplification is dependent upon the intensity of the bedrock motion. Amplification is greatest for low frequency (long wave) and smallest for high frequency (short wave) motion.

Detailed analysis of site soil conditions is not available for the entire area under County jurisdiction, nor are they necessary. However, a general study of regional geologic structure and potential ground response would be an ideal tool in assessing seismic and geologic hazards. As yet, state-of-the-art and the geologic complexity of San Diego County preclude the gathering of adequate data for this type of County-wide approach. For planning purposes in the future, it would be advantageous to have this type of data to identify ground response spectra for input into the design and engineering of major structures throughout the County.

Groundwater systems near active faults can be altered by seismic activity. Exact relationships are the subject of continued study at several universities. At present the basic understanding equates seismic activity with rejuvenation of springs and water tables. Water quality has also been affected in some instances when the presence of high sulphur content water has increased. (Hodgson, p. 52)

TSUNAMI AND SEICHE HAZARD

"Tsunamis are large scale ocean waves that are impulsively generated. Their generation is usually associated with strong seismic activity, volcanic explosions, or other large-scale impulses that the ocean may be subjected to. The waves are so long that even in the deepest ocean they travel as shallow water waves with velocities of about 500 miles per hour." (See Appendix C)

The popular notion of a "tidal wave" is identical with this definition; however, for scientific purposes the Japanese word for tidal wave was introduced to differentiate this phenomena from storm surges or the characteristics of other long-period wave activity. A tsunami event begins with the impulsive generation of long-period free progressive gravity waves, extending through their development and spreading throughout the ocean, concluding with their eventual dissipation.

Seiches are the surging of water within confined areas such as lakes or harbors. A seiche can be initiated by earthquakes or landslides and is reflected within the subject basin until dissipated.

Sources of Tsunamis

Tsunamis in the Pacific Ocean typically originate in the deep submarine trenches and the seismically active perimeter of the ocean's basin. (Shepard, p. 35) There is no record of tsunami effects greater than the normal tidal range in San Diego County. Historically, however, data only exists for waves which have approached oblique to the coastline. No event has originated in the Tonga or Mindanao regions of the Pacific in historic times, yet these regions are considered active and ". . . oriented so as to direct their tsunamis toward San Diego." (Joy, p. 23)

Although speculative, there is evidence to support the potential for severe locally generated tsunamis. "A seismic sea wave (Tsunami) initiated within the offshore California borderland is possible. Such a wave could have a damaging effect on low-lying shoreline areas along the Pacific Ocean and in the mouths of the bays." (McEuen, p. 53)

Previous tsunami potential studies for San Diego County have failed to adequately examine the nearshore and continental shelf bathymetry and yet have concluded that these features have mitigating effects on tsunamis. The tsunamis during our brief historic record have been dampened by the continental shelf because they have originated in the adjacent areas of the Pacific. Because there is no precedent for tsunamis having approached more directly at the coastline, the possibility has not been addressed.

The popular concept that faults in California are "principally of the strike slip variety" (Joy, p. 27) has fostered the conclusion that offshore faults could not produce a locally generated tsunami. The San Clemente Fault 40 miles offshore shows evidence of dip (vertical) separation oriented to propagate tsunamis directly at the coast. Even if the violent up-rush of water does not occur, strong currents can cause extensive harbor and coastal damage.

Measurable tsunamis have occurred in the Pacific "at the rate of one per year since 1800." Large tsunamis have occurred at an average rate of one per dozen years. (Joy, p. 23) On December 21, 1812, a large, locally generated tsunami originated among the Channel Islands which struck the Santa Barbara--Ventura coast. (Townley and Allen)

Sources of Seiche

Having no harbors within the County's jurisdiction, the only seiche hazard would be caused by earthquakes or landslides occurring in or near lakes and reservoirs. Such events may cause shoreline inundation, overtopping of dams, and some downstream flooding. At this time, however, there is no iminant danger from seiche hazards.

Means of Recognizing and Predicting Tsunami Hazard

In comparison with other natural disasters, tsunamis are unique. They do not behave like hurricanes, fires or other natural disasters. They strike in a limited area in a predictable manner and often with hours of advance warning. However, "In case a tsunami were generated nearby, the severe earthquake which signals the event itself may provide the only warning." (Joy, p. 28)

Under Public Law 80-373/August, 1947, the National Oceanic and Atmospheric Administration, through the National Oçean Survey, maintains the tsunami warning system. Presently, the warning channels are:

> From the Tsunami Warning Center in Honolulu by Defense Communications Agency circuits to 28th Office of Civil Defense Warning Center, Hamilton Air Force Base; by radio to the California Disaster Office. From the California Disaster Office by State Department of Justice teletype system to all police, sheriff and California Highway Patrol jurisdictions concerned. The San Diego Police notify the Unified Port District. (Disaster Preparedness, p. 91)

Tsunami warning and arrival times are:

> 12-20 hours when originating on opposite side of Pacific; 2-12 hours from adjacent areas; 5-20 minutes from local source - earthquake is only warning.

Characteristics of observed tsunamis are:

- height of successive waves may increase,
- behind shallow wave platforms or reefs, the height is less,
- unimpeded waves achieve greater heights,
- energy is dissipated up submarine canyons,
- energy is focused on submarine ridges,
- there is a great recession of water between waves. (Shepard, p. 28)

Wave energy orthogonals (lines) can be determined for the San Diego County Coast for an event from any source in the Pacific. "If wave refraction is taken into account, it is possible to predict wave conditions in coastal waters . . ." (Bird, p. 20)

DAMS AND DAM FAILURES

The sources of hazards from dams are of three major types: 1) failure of the dam structure during a seismic event; 2) overtopping caused by a landslide into the reservoir; and 3) seiching which was described above.

The State Department of Water Resources (DWR) is responsible for the safety of dams in California, other than those federally owned. In 1958, the Consulting Board for Earthquake Analysis was created to provide guidance in formulating and implementing a comprehensive program of seismological and earthquake engineering investigations.

The investigations undertaken fall into three categories: 1) identification and evaluation of earthquake-related hazards, 2) a study of seismic-related ground motions and deformation and the response of dam structures; and 3) design of dams that will withstand earthquake effects. The DWR also sponsors a strong-motion seismograph program.

The State Office of Emergency Services presently requires dam owners to prepare dam failure inundation maps and submit them to the local jurisdiction for use in land-use planning and for the preparation of disaster plans and evacuation procedures by early 1975. At that time, the Public Safety Element of the General Plan should be amended to observe any hazards which may be identified.

One final consideration in dams and dam failures is the danger of a landslide blocking a gorge creating a temporary dam by blocking the river or stream. The relative scarcity of flowing streams and the wide flood plains of most of the County's river valleys make this occurrence only a remote possibility.

Appendix B
Glossary

ACTIVE FAULT - An Active Fault is one that exhibits separation in historic time or along which separation of Holocene deposits can be demonstrated. If Holocene deposits are not offset, but numerous epicenters have been recorded on or in close proximity to the fault, a classification of active may be used.

BEDROCK - The solid, undisturbed rock in place either at the ground surface or beneath surficial deposits of soil.

DIFFERENTIAL SETTLEMENT - The uneven settlement of the ground at some elevation. It usually refers to unequal settlement under a structure or of a structures foundation. Large differential settlements are a source of serious damage to most structures.

DIP-SLIP - Type of fault movement in which the principal relative motion is in the vertical sense rather than the horizontal sense.

EARTHQUAKE - Perceptible trembling to violent shaking of the ground, produced by sudden displacement of rocks below and/or at the earth's surface.

EPICENTER - The geographical location of the point on the surface of the earth that is vertically above the earthquake focus. It is near the area of highest intensity shaking.

FAULT - A plane of breakage in rock or soil, along which significant (greater than an inch or so) offsetting of the two sides of the plane has taken place due to tectonic forces.

FAULT SEPARATION - Indicates the amount of dislocation of one side of a fault relative to the other side resulting from fault movement.

FAULT TRACE - The line of intersection of a fault surface with the earth's surface.

FOCUS - The point within the earth which marks the origin of the elastic waves of an earthquake.

GROUND RESPONSE - The reaction of the ground to bedrock shaking.

GROUND MOTION - Shaking motions of the soil or rock during an earthquake.

INACTIVE FAULT - A fault is classified Inactive when a fault trace exhibits no separation of deposits more recent than pre-Pleistocene, or for which no determination of activity can be made.

INTENSITY - Intensity refers to the degree or strength of shaking at a specified place. It is not based on the energy released by an earthquake but is a rating assigned by an experienced observer using a descriptive scale with grades indicated by Roman numerals from I to XII. Intensity is a rating of the severity of damage-producing properties of the ground motion at a specific location. The scale of measurement is based upon the sensations of persons and upon physical damage to structural and man-made objects. The most widely used and accepted intensity scale is the Modified Mercalli Intensity Scale.

MAGNITUDE - Magnitude is related to that energy which is radiated from the earthquake source in the form of elastic waves. Basically, magnitude is the rating of a given earthquake related to the earthquake energy released in the hypocentral area and is independent of the base of observation since it is calculated from measurements on seismograms. It is expressed in ordinary numbers and decimals. Magnitude was originally defined by C. F. Richter as a logrithm (base 10) of the maximum amplitude of a seismogram at a distance of 100 km (62 miles) from the focus. For other distances or for instruments of other types, conversion to the standard is accomplished.

MAJOR STRUCTURE - A major structure is defined as any structure having a capacity of 300 persons or more, a police or fire station, a school, a hospital or rest home, or any facility having the capacity to severely damage the environment if destroyed such as: dams and reservoirs, and petroleum storage facilities.

ORTHOGONAL - A line drawn perpendicular to the wave crests on a wave energy refraction diagram.

POTENTIALLY ACTIVE FAULT - A Potentially Active Fault is one that exhibits separation of Pleistocene deposits, but for which separation of Holocene deposits is lacking and for which seismic activity is nominal or absent.

PROJECT - Project means the whole of an action, resulting in physical impact on the environment, directly or ultimately, that is any of the following:

- an activity directly undertaken by any public agency including, but not limited to, public works construction and related activities, clearing or grading of land, improvements to existing public structures, enactment and amendment of zoning ordinances, and the adoption of local General Plans or elements thereof pursuant to Government Code Sections 65100 - 65700.
- an activity undertaken by a person which is supported in whole or in part through public agency contracts, grants, subsidies, loans, or other forms of assistance from one or more public agencies.
- an activity involving the issuance to a person of a lease, permit, license, certificate, or other entitlement for use by one or more public agencies (from California Environmental Impact Report guidelines Section 15037).

RECURRENCE INTERVAL - The average length of time between earthquake events of a specified magnitude. It is a statistical quantity and does not imply that the events will occur in that time interval.

SEISMIC - Pertaining to an earthquake or earth vibration, including those that are artificially induced.

SLOPE STABILITY - The ability of a slope of soil or rock material to resist moving downhill.

SURFACE RUPTURE - During an earthquake, the permanent displacement (or offset) of the earth's surface along a fault plane. Ground breakage at the earth's surface.

TECTONIC - Pertaining to rock structure resulting from deformation of the earth's crust.